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A Brief Analysis of the Characteristics of Industrial Hemp (*Cannabis sativa* L.) Seed Grown in Northern Ontario in 1998

May 19, 1999
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Acknowledgements

Thanks very much to Gordon Scheifele, Kemptville College/University of Guelph, Thunder Bay, Ontario not only for the data used in this report, but for the opportunity, encouragement, and support he has given me to learn about hemp and the importance of dedication. Thanks also to Dr. David Euler, Zsu Zsa Elchuk, Annie Moore, Jenn Bussey, Matt Gordon and all the growers who participated in the Northern Ontario Hemp Research Project.

This project was funded by the Northern Ontario Heritage Fund Corporation and was made possible by the cooperation of and funding from Quetico Centre; Thunder Bay Ventures; Rainy River Futures Development Corporation; Soil and Crop Improvement Associations from Sudbury, Thunder Bay, Dryden, Manitoulin Island, and Rainy River; Patricia Area Community Endeavors; Sudbury Regional Development Council; Sudbury Regional Development Corporation; LaCloche Manitoulin Business Assistance Corporation; Dryden Federation of Agriculture; Thunder Bay Co-op Farm Supply; Emo Feed Service; Kenex Ltd., and Kemptville College/University of Guelph.

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Executive Summary

The largest and most comprehensive hemp grain quality research project in Canada was conducted in northern Ontario in 1998 as part of a Northern Ontario Heritage Fund Corporation Hemp Feasibility and Production Research Project. The goal of the study was to establish the grain yield and quality potential across northern Ontario (a distance of over 2000 km from east to west and north and south between the 46th and 50th latitude) and to compare these data to existing literature on hemp grain yields and quality composition. Grain samples were analyzed for Fedora 19 (14), Felina 34(15), Fedrina 74(9), Zolotonosha 11(3), Zolotonosha 13(3), Secuieni 1(3), Irene(2) and Fin314(1). The bracketed numbers represent the number of sites sampled and analyzed. Grain samples (1 m2 plots) were hand harvested from 3 plots per variety and pooled for analysis. The grain samples were analyzed for oil, protein, fibre, amino acid and essential fatty acids by Dr. Roman Przybylski, University of Manitoba, Winnipeg, Manitoba.

- The overall average grain yield of 1.01 tonnes/hectare represents competitive values for hemp grain production in northern Ontario. The oil yield for all varieties reported was for grain at 10-12% moisture. Fedora 19, Felina 34 and Fedrina 74 yielded 27.9%, 28.8% and 26.8% oil respectively. Essential fatty acid profiles were very similar to those published for hemp varieties grown outside northern Ontario. The EFA profile for all the varieties examined was almost a precise 3:1 ratio of linoleic to linolenic acid. This is important for the development of markets for hemp seed grown in northern Ontario due to the pharmaceutical and nutritional interest in oils high in essential fatty acids, especially the omega 3 and omega 6 ratio of 3:1. The Finish variety, FIN 314, exhibited significantly higher values than other varieties for GLA and stearidonic acid. This study suggests that hemp grain can be produced competitively in northern Ontario both for yield and quality comparable to those of other hemp growing regions.

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Introduction

The 1990's have seen a renewed and increasing interest in the growing and processing of industrial hemp (*Cannabis sativa* L.) in western Europe and North America. This is evidenced by the proliferation of hemp magazines, retail stores, research efforts, hemp growers, and processing equipment and facilities. Mari Kane (1997) lists over 200 hemp based businesses operating in North America in 'Hemp Pages: The Hemp Industry Source Book', and notes that many more entrepreneurs and existing businesses enter the market every year. The snowballing market for hemp products, and the suitability of this crop to a wide range of environments has led researchers from across Canada to initiate agronomic studies of hemp. It is reported that 21 hemp research licenses, and 241 commercial hemp licenses were issued in Canada in 1998, and that hemp was grown in every province with the exception of Newfoundland (Crawford, 1998).

The largest of these research projects was conducted in northern Ontario by Gordon Scheifele of the University of Guelph. Data acquired from this project will be used in the development of a feasibility study to determine the potential for a hemp industry in northern Ontario. It is generally thought that the initial focus of a hemp industry in northern Ontario will be the production of hemp grain for further processing into oil and other seed by products. It is the goal of this report to analyze the yield and composition of hemp seed grown at sites throughout northern Ontario and to compare this data to the existing literature on hemp seed yields and composition. This will help to determine whether northern Ontario can be competitive with other hemp growing regions in terms of production capacity and seed quality. A literature review will reveal existing data on hemp seed yields and composition as well as examining some potential markets, and obstacles to a hemp industry in northern Ontario.

Currently, Lakehead University, the University of Guelph, the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA), the Thunder Bay Hemp Growers Association (TBHGA), the Red Sky Metis Organization, and several regional economic development groups are working together to define a strategic direction for a hemp industry, and are making plans for the 1999 growing season. A concise presentation of hemp seed production potential and quality may assist the above groups in making decisions for the coming years regarding varietal choices, production goals, market opportunities, and local processing.

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Methodology

A literature review was conducted to find existing data on the composition of hemp seed and hemp seed oil, as well as information regarding some of the potential markets, products, and possibilities that are available to hemp seed producers.

Data used in this report are taken from the Northern Ontario Hemp Research Project which was designed and supervised by Gordon Scheifele of the University of Guelph. Hemp seed samples were collected from eight varieties of industrial hemp grown at 32 locations throughout Northern Ontario. Twenty seven of the sites were five acre strip trial sites, where four varieties of industrial hemp (Felina 34, Fedrina 74, Secuieni, Irene) were cultivated for grain production. Five of the sites were research locations operated by the University of Guelph and the Ontario Ministry of Agriculture, Food, and Rural Affairs, where other varieties were examined (Zolotonosha 11 and 13, Fedora 19, FIN-314). Grain samples were collected from three one square meter (m^2) plot for each variety and at each location. These were averaged and then extrapolated to produce a yield value in tonnes/hectare. Ten gram samples of each variety were sent to the University of Manitoba to be analyzed for oil, protein, fibre, and amino acid content. The analysis was performed by Dr. Roman Przybylski using recognized techniques for extraction and analysis.

Data are summarized by variety across all locations in order examine potential varietal differences in hemp seed composition and oil yields. Due to the broad range of growing conditions, soil types, and fertilizer application it would be difficult to examine a geographic difference in yield or oil quality within northern Ontario. For this reason data has been averaged across the region, which will facilitate a broader comparison to the characteristics of hemp seed produced in other parts of the world.

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Literature Review

In June, 1994 the first modern hemp crop in North America was grown on 6 acres of land in southern Ontario (Sumach, 1995). Since then the interest of Canadian farmers and researchers has exploded, and in 1998 over 2500 hectares (5500 acres) were cultivated for commercial and research purposes across Canada (Crawford, 1998). The largest of the research projects was conducted in Northern Ontario and evaluated 11 varieties of industrial hemp at 32 locations from Rainy River to Sudbury. This research will provide a large data base and set the stage for a potential hemp industry in Northern Ontario. It is generally believed that the development of a hemp industry in Northern Ontario will begin with a focus on producing hemp seed for processing into oils and other by-products. This is due to the higher value of seed and oil compared to hemp fibre in today's market , and to the fact that hemp seed can be processed using existing equipment while processing of hemp fibre will require new facilities and equipment.

Although universally called hemp seed, the fruit of the hemp plant is technically a small nut (Bocsa and Karus, 1997), and is reported to contain 25 % to 35 % oil by volume (White, 1997). A growing interest in hemp seed and oil is due in large part to it's unique characteristics of containing essential fatty acids in a ratio that perfectly matches human nutritional requirements (Jones, 1995). Weil (1993) notes that essential fatty acids (EFA's), which are beneficial to human health, cannot be manufactured by the human body and must be acquired from external sources. The predominant EFA's in hemp oil are the unsaturated linoleic and linolenic acids, but many other types are present, including gamma linolenic acid (GLA) which is of increasing pharmaceutical interest (Molleken and Theimer, 1997). Although other oils, particularly fish and flaxseed oils also contain EFA's, Wirtshafter (1994) notes that these oils have unpleasant flavors as compared to the mellow and slightly nutty flavor of hemp seed oil. Przybylski et al (1998) feel that interest in hemp seed oil is increasing and that markets for specialty oils are growing fast as consumers are becoming more concerned about diet and health.

Oil for human consumption is certainly not the only market for hemp grain in Canada and the United States. Many other products can be made from the seed, and the oil can be used in a wide variety of applications. Roulac (1997) notes hemp seed oil blends easily with other substances, and can be used as a base to produce lubricants, paints, dyes, soaps, shampoos, cosmetics, and detergents. The seed can also be ground into flour and used to produce all sorts of baked goods, or can be processed into milk, cheese, ice cream, margarine and food supplements. Conrad (1994) states that hemp seed can be fed raw to many animals, including fish, farm animals, and wild birds. The high oil content of hemp seed makes it particularly attractive to many species of birds (Jones, 1995), and the growing bird watching industry may provide an important market for raw hemp seed. The meal remaining after the seed has been pressed for oil is high in protein and can be fed to farm animals as a supplement to an existing diet (Jones, 1995). Although little data is available regarding hemp seed meal as animal feed, Droppo (1984) states that flaxseed meal, which is similar to hemp seed meal in protein and fat content, can be used as the sole protein supplement for dairy cows. Further investigation is necessary, but this may prove to be a valuable by-product for hemp seed processors and farm animal producers in northern Ontario.

It has been noted by Przybylki et al. (1998) that climatic conditions can affect the composition of seed oils, and that seed yields and oil content depend on seed variety and growing conditions (Marcus,1998). This suggests that some regions may be better suited than others for the production of high quality hemp seed. Molleken and Theimer (1997) note that hemp varieties grown in temperate or cold regions exhibit higher levels of the valuable GLA than hemp varieties grown in warm climates. The relatively cool climate of Northern Ontario may enhance this characteristic. To some degree, it seems likely that the composition of hemp seed and hemp seed oil will have some impact on its end use. That is, seed higher in linoleic, linolenic, and gamma linolenic acids will be preferred for use in products developed for human consumption, and would be of greater interest to producers. For this reason it is important to determine which varieties demonstrate higher levels of these acids, and whether hemp seeds produced in Northern Ontario exhibit desirable fatty acid profiles.

White (1997) notes that there is little hard agronomic data available on hemp production in Canada.

Although significant commercial hemp crops were grown in Ontario and Manitoba in 1998, no data was available regarding the yield and composition of oils pressed from these seed crops. Data published by Jones (1995), Wirtshafter (1994), and Weil (1993) indicate that oil from hemp seed contains between 54% and 60% linoleic acid, 18% to 20 % linolenic acid, and 1% to 2% gamma linolenic acid. Callaway et al. (1996) reported that a variety called FIN-314 exhibited a GLA content of 4%. Ongoing research in Canada and around the world will eventually provide more data which will enable further comparisons between hemp seed grown in Northern Ontario and hemp seed grown in other regions.

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Results and Discussion

Seed Yields

Table 1 summarizes the hemp seed yields in tonnes/hectare for five varieties and in five regions of northern Ontario. The overall average yield for all varieties and all locations is 1.01 tonnes/hectare. Marcus (1998) notes that the average expected yield for hemp seed range from 0.7 to 1.2 tonnes/hectare, and found these yields to be acceptable from an economic perspective. Average yields for the varieties Fedrina 74, Felina 34, Fedora 19, Secuieni 1, and Irene were 1.23, 1.1, 1.02, 1.03, and 0.74 tonnes/hectare respectively. Scheifele et al. (1999) note that Secuieni 1 and Irene show a strong tendency to exceed the legal limit of 0.3 % THC content, and have been removed from the Health Canada list of approved cultivars. Growers will not be permitted to produce Secuieni 1 and Irene in the future, but Fedrina 74, Felina 34, and Fedora 19 have been approved by Health Canada and will be available to farmers in 1999. All three of these varieties exhibited average yields greater than 1 tonne/hectare. This suggests that these varieties have good potential for cultivation as a seed crop in northern Ontario. Marcus (1998) and White (1997) note that production in Manitoba has ranged from 750 to 1750 kg/hectare, but no data was available to make varietal comparisons.

It is impossible to infer any geographic or climatic effect on seed yield from these data, since samples were averaged over a wide range of soil types, geographic locations, fertilizer applications, and weather patterns. Scheifele (1996) has noted that soil type, fertility, drainage, and moisture are critical factors in the growth of hemp. Growing conditions will certainly have a large effect on seed yield, regardless of the variety or geographic location of the hemp crop.

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Oil, Fibre, and Protein Content

Oil, fibre, and protein content of hemp seeds are listed in Table 2. The percentage oil is determined by pressing the maximum amount of oil out of the whole seeds, and protein and fibre content are determined for the seed meal which remains after the oil has been extracted. The highest average oil yield was 28.85 %, produced by Secuieni 1, a variety which will not be legal to cultivate in Canada in the future. The values for average oil content ranged between 24.97 % and 28.85 %. These values are generally low compared to the 30 %-32 % average oil content reported by Bocsa and Karus (1997) for industrial hemp. In a personal discussion with Gordon Scheifele he reported that the hemp samples used for this report were dried to approximately 12 % moisture prior to the oil extraction process. The standard practice is to dry hemp grain to about 5% moisture prior to pressing in commercial applications. Scheifele feels that the high moisture content of the seeds used in this analysis could have caused a decrease in the percentage values of as much as 3 %.

An interesting result of the oil content analysis was the low value (26.2%) exhibited by FIN-314. Callaway et al. (1996) reported that this variety contained as much as 37 % oil by weight, and although only one sample was analyzed for this report, it is surprising to find such a low value. This may be due to the fact that this variety was not planted until early in July due to unavailability of seed stock. The seed of FIN-314 was harvested after only about 60 days of growth, compared to 110-120 days for most other varieties.

The protein content of the hemp seed meal ranged from 32.9 % for Irene to 35.8 % for FIN-314. Jones (1995) reports a value of 30.76 % protein content as an average value for industrial hemp. The protein content of hemp seed meal is significantly higher than that of alfalfa hay or barley, which are commonly used as animal feed in northern Ontario. Hemptech (1995, pg.27) reports an approximate protein content of only 25 % for hemp seed cake, and states that it "makes an excellent feed for domestic animals as well as cows and chickens". The high protein content reported for hemp seed grown in northern Ontario suggests that this by-product of oil production would be of value to local livestock producers. Again, comparison to other hemp varieties grown elsewhere in Canada is not possible at this time, and geographic differences in protein content of hemp seeds

cannot be inferred. This will also require further investigation, and may prove to be another attribute of producing hemp in the cool climate of northern Ontario.

Fibre content of the hemp seed cake ranged from 28.1 % for FIN-314 to 30.5 % for Zolotonosha 11. The differences between varieties were small, and the overall average of 29.06 % fibre content can be accepted as a good general value. The literature review did not reveal any other reports of hemp seed cake fibre content or any particular importance of the fibre in hemp seed. However, since fibre is an important part of both human and animal nutrition it seems that this characteristic of hemp seed could also be of value to livestock producers. The complete amino acid profile for the seed meal after oil extraction is summarized in Table 6.

Table # 1: Seed Yield of Industrial Hemp Varieties Grown in Northern Ontario (Tonnes/Ha)

	Variety					
Region	**Felina 34**	**Fedrina 74**	**Secuieni**	**Irene**	**Fedora 19**	**Average**
Thunder Bay	0.84	0.77	0.63	0.61	n/a	0.71
Rainy River	1.06	1.46	1.09	0.87	n/a	1.12
Dryden	0.87	0.79	n/a	n/a	1.02	0.89
Sudbury	1.57	1.86	1.37	n/a	1.19	1.50
Manitoulin Island	1.16	1.26	n/a	n/a	0.84	1.09
Average	1.1	1.23	1.03	0.74	1.02	-

Table # 2: Percentage Oil, Protein, and Fibre Content of Industrial Hemp Varieties Grown in Northern Ontario

Variety	**# of Samples**	**% Oil**	**% Protein**	**% Fibre**
Felina 34	15	28.80	34.4	29.17
Fedrina 74	8	26.80	34.0	28.26
Secuieni 1	2	28.85	34.7	29.65
Irene	2	28.60	32.9	28.7
Fedora 19	13	27.90	34.6	28.66
Zolotonosha 11	3	25.50	34.67	30.50
Zolotonosha 13	3	24.97	34.47	29.47
Fin 314	1	26.20	35.80	28.10
Average	47	27.20	34.44	29.06

Table # 3: Essential Fatty Acid Profile of Eight Industrial hemp Varieties Grown in Northern Ontario

Variety	**# of environments**	**Linoleic Acid (Omega 6)**	**Gamma Linolenic Acid (GLA)**	**Linolenic Acid (Omega 3)**	**Ratio of Linoleic Acid to Linolenic**
Felina 34	16	55.43	2.16	18.09	3.1 : 1
Fedrina 74	8	55.34	2.41	18.03	3.1 : 1
Secuieni 1	4	56.24	1.73	17.38	3.2 : 1
Irene	2	55.49	2.13	17.64	3.1 : 1
Fedora 19	14	55.40	2.19	17.8	3.1 : 1
Zolotonosha 11	3	55.60	2.22	17.42	3.2 : 1
Zolotonosha 13	3	56.11	2.51	17.99	3.1 : 1
FIN 314	1	53.60	4.22	18.75	2.9 : 1

Table # 4: EFA Profile of Industrial Hemp Varieties from around the World

	Percent Content		
Variety (Location)	Linoleic Acid (Omega 6)	Gamma Linolenic Acid (GLA)	Linolenic Acid (Omega 3)
FIN 314** (Finland 1997)	54.8	4.1	19.2
FIN 314** (Quebec 1998)	53.8	4.7	19.9
Unknown* (Lebanon)	50.66	0.34	15.43
Unknown* (Germany)	55.45	4.25	15.82
Unknown* (Turkey)	49.56	2.52	17.36
Unknown* (Colombia)	56.06	0.64	19.24
Hemp** (Typical)	55-59	5-2	19-21

* Adapted from: Molleken and Theimer(b) (1997)
**Courtesy of Sasha Pryztyk (Gen-X ltd.)

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Essential Fatty Acid Profile

Average values for the essential fatty acid profiles of hemp seed oil from eight varieties of industrial hemp are given in Table 3. The values for linoleic acid (omega-6), gamma linolenic acid (GLA), and linolenic acid (omega-3) fall well within the values for other hemp varieties around the world (see Table 4). It is particularly interesting to note that the ratio of omega-3 to omega-6 fatty acids are almost exactly three to one (Table 3) for all varieties. This is the nutritionally optimum ratio for human health, and Jones (1995) feels that a precise three to one ratio will be desirable for future production of hemp seed for human consumption. Table 5 provides the complete fatty acid profile for the eight varieties of industrial hemp. The N refers to number of sites averaged and Felina 34 and Fedora 19 had 15 and 14 sites averaged respectively.

Again, geographic effects cannot be detected from these data due to the large sampling range and averaging of EFA content across this range. Varietal differences appear minute, the only exception being FIN-314 which exhibits a GLA content of 4.22 %. This result concurs with Callaway et al. (1996) who reported a GLA content of 4 % in samples of FIN-314 seed. The high GLA content of FIN-314 relative to the other varieties examined in this report warrants further investigation and trials of this variety in northern Ontario. This may prove to be an important characteristic as GLA is of particular interest to the pharmaceutical industry.

Przybylski et al. (1997) demonstrated that European varieties grown in Manitoba showed a ten percent increase in linolenic acid and GLA content compared to the original seeds. Such a comparison was not possible for the data presented in this report since the original seeds were not analyzed for fatty acid content, and future studies will be necessary to test whether seeds grown in Northern Ontario show increased EFA content over the original European seeds.

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Conclusions

Although seed yields varied widely between individual samples, overall averages indicate that yields for hemp seed grown in northern Ontario were within the average values suggested in existing literature. The overall average of 1.01 tonnes/hectare suggests that given desirable field conditions, hemp grown in northern Ontario can produce seed yields that are competitive with other regions.

Oil content for all varieties examined was slightly lower than could be expected, but this was likely due to high moisture content in the seeds when the oil was extracted. Oil yields may vary depending on the variety, growing conditions, moisture content, and the extraction method used. Of the approved cultivars for 1999, Felina 34, Fedora 19, and Fedrina 74 had the highest concentrations of oil with 28.8 %, 27.9 %, and 26.8 % respectively.

Essential Fatty Acid profiles were also very similar to those published for hemp varieties grown outside of northern Ontario. The most intriguing aspect of the EFA profile was the almost precise 3 : 1 ratio of linoleic to linolenic acid for all varieties examined. This may be important in developing

markets for hemp seed grown in northern Ontario due to the pharmaceutical and nutritional interest in oils high in Essential Fatty Acids, and particularly in the omega 3 to omega 6 ratio.

In general, the characteristics exhibited by hemp seeds grown in northern Ontario were very similar to those of hemp varieties grown in other parts of the world. The values for oil content, EFA profiles, and yields were well within the values published in existing literature on hemp seed, and it would seem that hemp seed production in northern Ontario could be competitive with other regions. The French varieties Felina 34, Fedrina 74, and Fedora 19 have been shown to have acceptable yields, oil content, and EFA profiles. The Finnish variety FIN-314 warrants further investigation, and is likely to receive much attention in the future.

There are certainly still financial, technical, and infrastructure considerations that are necessary before an industry based on hemp grain production can thrive in northern Ontario, but agronomically the potential exists. The increasing interest in the nutritional value of hemp oil combined with growing markets for hemp seed in the United States, and a ban on hemp production there, may provide markets for hemp seed produced in northern Ontario. The research conducted in 1998 by Gordon Scheifele, on which this report is based, has demonstrated that hemp can be successfully cultivated in northern Ontario. This analysis suggests that hemp seed produced in northern Ontario exhibit characteristics that are considered desirable for certain markets, and that yields can be comparable to those of other hemp growing regions. Certainly, the analysis did not reveal any data which would suggest that a hemp seed industry is not possible in northern Ontario, and only further research and the dedication of growers and entrepreneurs will determine whether a hemp industry develops in northern Ontario.

Table # 5: Fatty Acid Composition of Hemp Oil Extracted from Hemp Seeds Grown in Northern Ontario (Percentage of acids in oil)

Variety	N	16:0	16:1	18:0	18:1	Linoleic[6] 18:2	GLA 18:3	Linolenic[3] 18:3	18:4	20:0	20:1	22:0	24:0
Felina 34	1555	6.24	0.14	2.62	12.51	55.51	2.23	18.09	0.84	0.86	0.44	0.36	0.17
Fedrina 74	9	6.23	0.14	2.73	12.31	55.38	2.35	18.05	0.91	0.87	0.45	0.38	.017
Secuieni 1	3	6.07	0.13	2.61	13.02	56.4	2.02	17.23	0.71	0.84	0.44	0.36	0.17
Irene	2	6.13	0.14	2.77	12.98	55.49	2.13	17.65	0.76	0.92	0.46	0.4	0.2
Fedora 19	14	6.28	0.14	2.69	12.56	55.36	2.21	17.94	0.88	0.87	0.45	0.38	0.15
Zolotonosha 11	3	6.21	0.15	2.68	13.19	55.59	2.21	17.42	0.85	0.87	0.43	0.37	0.17
Zolotonosha 13	3	6.18	0.14	2.55	11.79	56.11	2.51	17.99	0.97	0.82	0.42	0.35	0.17
FIN 314	1	6.24	0.13	2.35	11.29	53.46	4.22	18.75	1.53	0.92	0.48	0.42	0.21

Abbreviations: 16:0 - palmitic; 16:1 - palmitoleic; 18:0 - stearic; 18:1 - oleic; 18:2 - linoleic (omega 6); 18:3 - gamma linolenic (GLA); 18:3 - alpha linolenic (omega 3); 18:4 - stearidonic; 20:0 - arachidic; 20:1 - eicosenic, gadoleic; 22:0 - behenic; 24:0 - lignoceric.
N = # of Environments

Table # 6: Amino Acid Composition of Hemp Seed Meal from Hemp Seed Grown in Northern Ontario. (Percentage in hemp meal after oil removal)

Variety	N	ASP	THR	SER	GLU	PRO	GLY	ALA	VAL	MET	ILE	LEU	TYR	PHE	HIS	LYS	ARG
Felina 34	15	3.38	1.14	1.64	5.38	1.33	1.32	1.31	1.11	0.74	0.80	1.83	0.76	1.25	0.72	1.20	3.28
Fedrina 74	9	3.38	1.10	1.55	5.23	1.30	1.18	1.25	1.08	0.72	0.81	1.67	0.71	1.25	0.70	1.19	3.28
Secuieni 1	3	3.35	1.13	1.75	5.62	1.40	1.37	1.37	1.05	0.74	0.82	1.73	0.75	1.29	0.74	1.17	3.40
Irene	2	3.58	1.21	1.71	5.52	1.32	1.50	1.36	1.16	0.76	0.76	2.02	0.79	1.35	0.76	1.23	3.53
Fedora 19	14	3.70	1.24	1.66	5.81	1.40	1.39	1.37	1.20	0.77	0.90	1.96	0.77	1.37	0.80	1.31	3.71
Zolotonosha 11	3	3.34	1.11	1.55	5.32	1.40	1.40	1.27	1.13	0.71	0.82	1.73	0.79	1.23	0.68	1.10	3.29
Zolotonosha 13	3	3.57	1.22	1.55	4.94	1.25	1.45	1.40	1.22	0.75	0.85	2.02	0.77	1.29	0.73	1.22	3.32
FIN 314	1	3.48	1.22	1.71	5.35	1.49	1.34	1.28	1.01	0.68	0.80	1.85	0.84	1.23	0.61	1.03	3.16

Abbreviations: ASP - Aspartate; THR - Threonine; SER - Serine; GLU - Glutamate; PRO - Proline; GLY - Glycine; ALA - Alanine; VAL - Valine; MET - Methionine; ILE - Isoleucine; LEU - Leucine; TYR - Tyrosine; PHE - Phenylalanine; HIS - Histidine; LYS - Lysine; ARG - Arginine
N = # of Environments

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Last Updated: March 9, 2000